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# **PROPULSION DIRECTORATE**

## **Monthly Accomplishment Report November 2004**

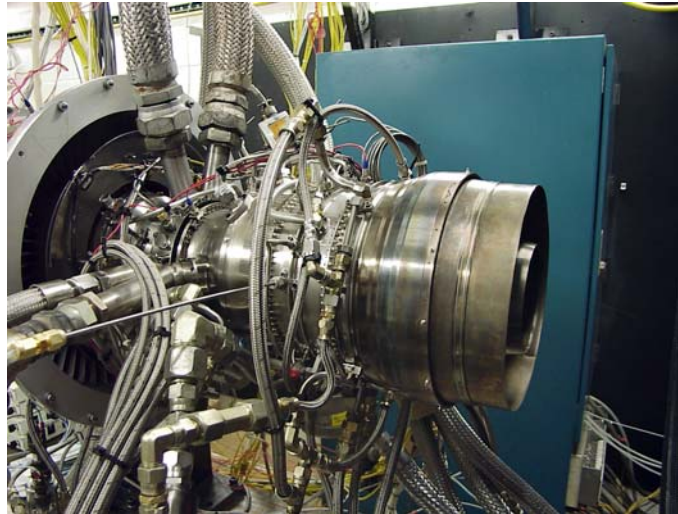
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### TEST ENGINE DEMONSTRATES REDUCED FUEL CONSUMPTION:

Testing of the XTC87/2 Joint Expendable Turbine Engine Concepts (JETEC) demonstrator engine was recently completed at [Williams International](#) in Walled Lake, Michigan. This testing was conducted in support of the DoD Integrated High Performance Turbine Engine Technology (IHPTET) Program. The JETEC portion of the IHPTET Program focuses on expendable and limited life engine technologies for applications such as missiles and unmanned aerial vehicles (UAVs). Testing of the XTC87/2 advanced the state of the art by achieving a 29% reduction in engine specific fuel consumption (SFC) (the IHPTET Phase II goal is 30%). This is particularly noteworthy because the SFC goal has proven to be the most difficult to achieve for all of the IHPTET engine classes, and improvements in SFC translate to increased range. These tests also successfully demonstrated steady-state performance, durability, and robustness of uncooled ceramic turbine blades at temperatures as high as 870 °F above the IHPTET baseline. (Mr. J. Kaufman, AFRL/PRTP, (937) 255-7331)



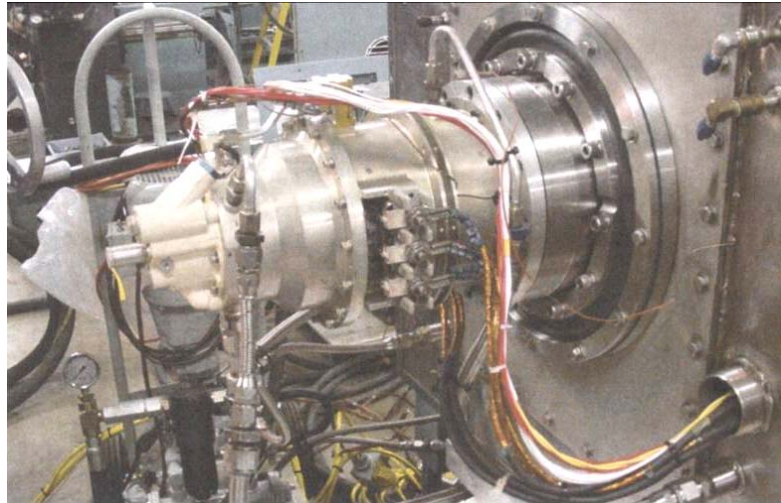
The XTC87/2 on the test stand



Ceramic turbine blades demonstrated in the XTC87/2

GLOBAL HAWK GENERATOR SIMULATES ALTITUDE OPERATION: The Propulsion Directorate's Power (AFRL/PRP) and Turbine Engine (AFRL/PRT) Divisions have jointly managed the development of a 75-kW rated generator for future application in the RQ-4 Global Hawk. The "LP Generator" (so named for being direct-driven by the low-pressure, or LP, engine fan spool) successfully demonstrated engine-installed operation at sea-level conditions during tests at Rolls-Royce Engines in 2003. To enable technology transition of the generator, however, it must also demonstrate its operability at Global Hawk mission altitudes. As a precursor to engine-installed tests at simulated mission altitudes, the Power Division coordinated with the generator vendor, [Innovative Power Solutions](#) (IPS) LLC, to first perform stand-alone tests of the LP Generator at simulated high altitudes (i.e., low air density). IPS arranged its tests to be performed on a special "depressurized" drive stand at the Naval Test Center. The initial test goal was to observe for possible corona discharge effects. While corona effects were not seen, the low air density conditions showed that certain components did not have sufficient air convection cooling and were at risk of overheating. IPS performed mechanical revisions to allow better heat

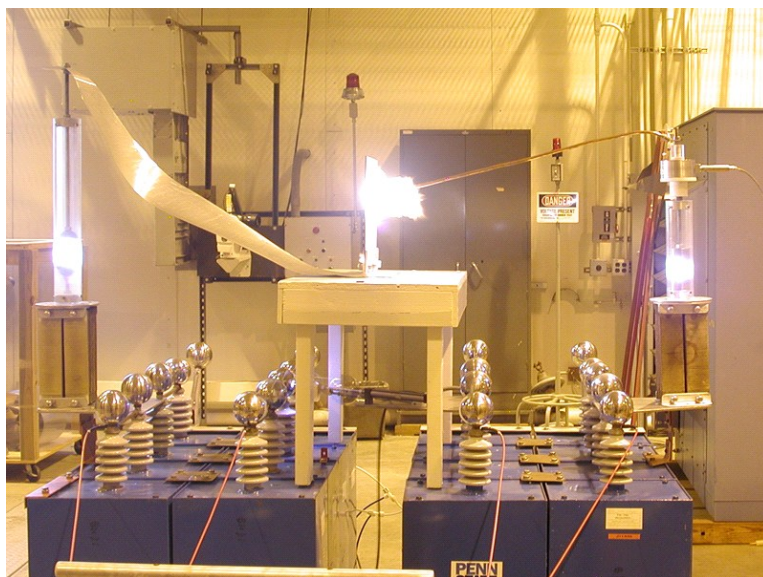
transfer for these components, and the recent follow-on tests demonstrated that the revisions were successful, as the LP Generator maintained its rated power through the scheduled 60-hour endurance test at low air density. This milestone achievement enables the LP Generator to be tested with the Global Hawk AE 3007H engine for engine-installed operation at simulated mission altitudes in 2005. (Mr. E. Durkin, AFRL/PRPG, (937) 255-6206)



The LP generator was successfully tested at simulated Global Hawk mission altitudes

#### ENHANCING SURVIVABILITY AND MAINTAINABILITY FOR THE C-17 TRANSPORT:

On 1-2 December 2004, the Propulsion (AFRL/PR) and Materials & Manufacturing (AFRL/ML) Directorates initiated a collaborative effort to address solutions to lightning strike repairs and attachment event mitigation for the C-17 transport. An increasing occurrence of attachment events has led Boeing and ML to investigate alternative approaches to lightning strike susceptibility and structural damage mitigation and repair on composite sections of the vehicle's skin. The current hybrid material design utilizes conductive copper mesh embedded in carbon composite skin. While this has a certain level of survivability, the process for repairing a damaged attachment site is difficult at best (in the field) and it does not satisfactorily ensure electrical bond integrity in the repaired area. Collaboration between ML and the National Composite Center produced ten sample carbon composite panels, each with its own unique construction, with an emphasis on using layers of nanofilamentary metals, metallic coated carbon nanotubes, nickel nanostrand veils, and metallic expanded mesh. PR's unique pulse



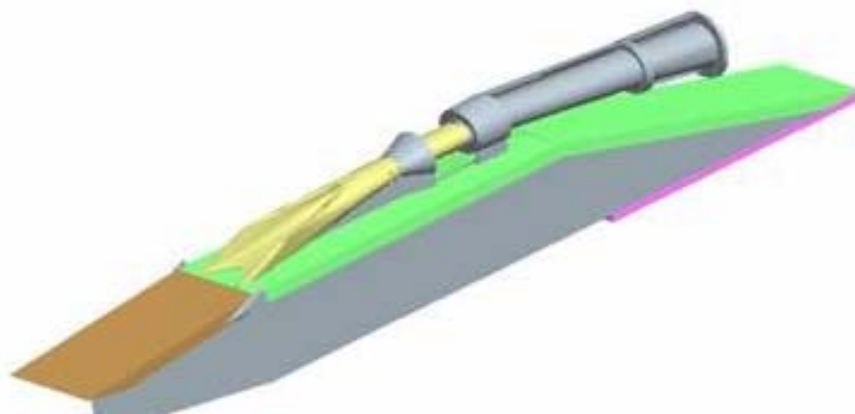
Lightning strike testing will help improve C-17 survivability

current generator facilities were used to deliver impulse currents of about 20,000 amps peak amplitude, in order to simulate attachment events on the samples. Prior to these impulse tests, full characterizations of surface and subsurface morphology were done on each sample in ML facilities. These characterizations will now be repeated to identify the damage to each panel, in addition to the visual inspections documented after each impulse event. This first round of evaluations will lead to additional optimized samples, which will be exposed to similar



impulse tests in the months ahead. (Dr. D. Schweickart, AFRL/PRPG, (937) 255-9189 and Dr. J. Horwath, AFRL/PRPG, (937) 255-9190)

SCRAMJET PERFORMANCE BENEFITS FROM ELLIPTICAL COMBUSTOR: The Propulsion Directorate recently completed the Robust Scramjet Elliptical Combustor Program with [ATK-GASL](#). In this program, a NASA hydrogen-fueled non-rectangular scramjet engine was modified to operate using a hydrocarbon fuel. This engine was then integrated into a hypersonic missile airframe to determine performance of the integrated engine-vehicle design. The purpose of this effort was to evaluate the viability of this non-rectangular hypersonic airbreathing propulsion system, referred to as the Elliptical Combustor Scramjet (ECS). The specific objectives of this task were to determine integrated performance of the ECS after integration to a baseline missile airframe, and to exercise and modify design tools to make performance and operability enhancements to the existing elliptic-combustor scramjet flowpath for low Mach number and on-design operation. The overall results of this study showed that the ECS will provide system performance benefits over conventional rectangular engines for cruise missile applications and hypersonic reconnaissance and strike aircraft. (Dr. C. Raffoul, AFRL/PRAT, (937) 255-7317)



The Elliptical Combustor Scramjet

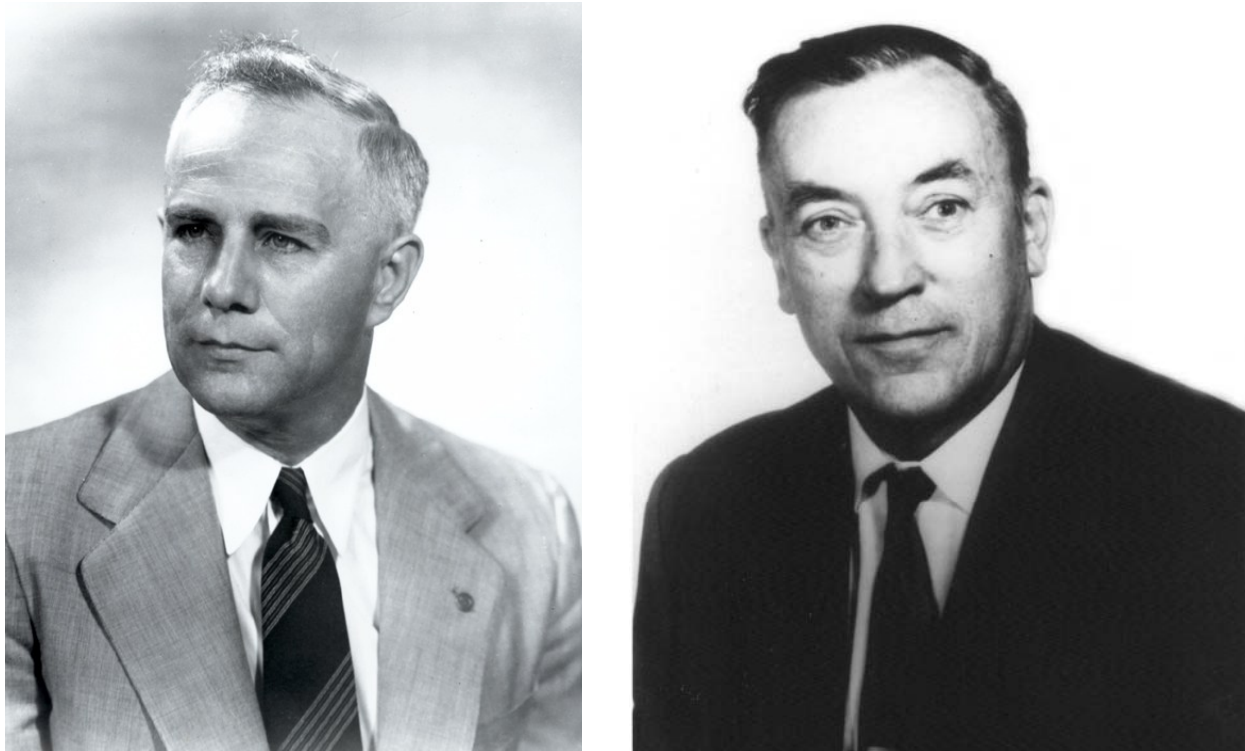
EXEMPLARS ROOM DEDICATED: On 24 November 2004, the Propulsion Directorate at Wright-Patterson AFB dedicated their Building 18's Main Conference Room as the "Exemplars Room." This dedication and name change was made in recognition of this directorate's two Department of Defense Exemplars, Mr. Daniel Adam Dickey and Mr. Ernest Clifford "Cliff" Simpson. Plaques for the first nine Exemplars were unveiled in a ceremony at the Pentagon in May 2004. Messrs. Dickey and Simpson were the only two Air Force employees chosen for this honor from the thousands of nominations received. Remarkably, both Air Force Exemplars are also alumni of the Propulsion Directorate. The Exemplars represent DoD's highest standards of career civilian excellence, and additional Exemplars will be selected only once per decade. Mr. Dickey was recognized for the critical role he played in assuring US preeminence in the field of aircraft propeller design and development. In 1943, he received the first Defense Emblem of Exceptional Civilian Service Medal from then Secretary of War Henry Stimson. Mr. Simpson served in the US Army during World War II, and he then spent 34 years as an engineer in the Propulsion Directorate before retiring in 1980. He played an integral role in advancing the technology of high bypass ratio turbine engines which enabled the C-5 Galaxy and

revolutionized commercial air travel worldwide. He received the Distinguished Civilian Service Award, the highest honorary award a civilian employee of the Department of Defense can receive, and he was also a joint recipient of the prestigious Goddard Award in 1968. (Mr. S. Cloyd, AFRL/PROP, (937) 255-0158)

Want more information?

❖ A *Skywrighter* article\* on this event is available here:

<http://www.skywrighter.com/people/2004/1203/11dedicatesroom.asp>



Mr. Daniel Adam Dickey (L) and Mr. Ernest Clifford "Cliff" Simpson (R) were two of the first nine individuals named as Department of Defense Exemplars

#### HIGH PRECISION MIRRORS ASSEMBLED FOR SOLAR THERMIONIC DEMO:

Representatives from Universal Energy Systems, Inc. (UES), General Atomics (GA), NASA, and the Propulsion Directorate recently met at NASA's Marshall Space Flight Center (MSFC) in Alabama. The team is developing and testing thermionic power technology (i.e., thermal-to-electric conversion) to be employed in a 50 kW advanced space power system with a large inflatable solar concentrator. The purpose of this gathering was to assemble and install 30 heliostat mirror panels on a ground-based solar concentrator system at MSFC. These mirrors will be used to track and reflect sunlight onto a large array of concentrating mirrors which will provide the thermal source for a ground demonstration of a single 100 W cylindrical inverted thermionic converter. Due to the high optical precision specification of the heliostat and the fragility of the lightweight components, the assembly required careful engineering and

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\* Cooper, Mindy, "AFRL Dedicates Exemplars Room," *Skywrighter*, December 3, 2004, p. 11A.



Refurbishing of Solar Concentrator Test Facility at NASA Marshall Space Flight Center

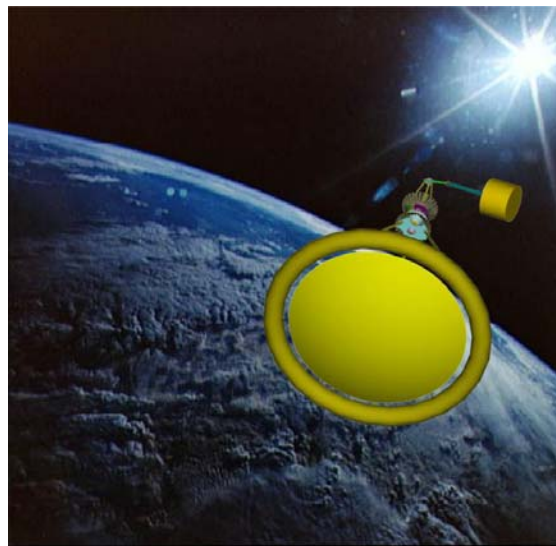
meticulous labor. The solar thermionic ground demonstration now only awaits final alignment of the heliostat with respect to the concentrator. (Dr. S. Adams, AFRL/PRPE, (937) 255-5179)

**NEW COLLABORATION TO INVESTIGATE AC TOLERANT HIGH TEMPERATURE SUPERCONDUCTORS:**

Performance of high temperature superconductors suffers severely in alternating magnetic fields, hampering their use for applications such as transformers and generators. To address this issue, a multidirectorate collaborative research endeavor was recently started involving AFRL's Propulsion and Materials and Manufacturing Directorates and the company [SuperPower, Inc.](#) The purpose of this collaboration is to investigate eight different complementary techniques to reduce AC losses in



Schematic showing the various layers of HTS wire



A conceptual image of a Solar Thermionic Space Power System



Assembly of new heliostat mirrors at NASA Marshall Space Flight Center

1 m to 10 m superconducting wire lengths. Upon completion of this effort, slated for the end of FY06, the factors granting the largest reductions will be chosen and incorporated into the production of superconducting wire. These modifications are expected to increase the current carrying capacity of the wire by orders of magnitude. There is also an option

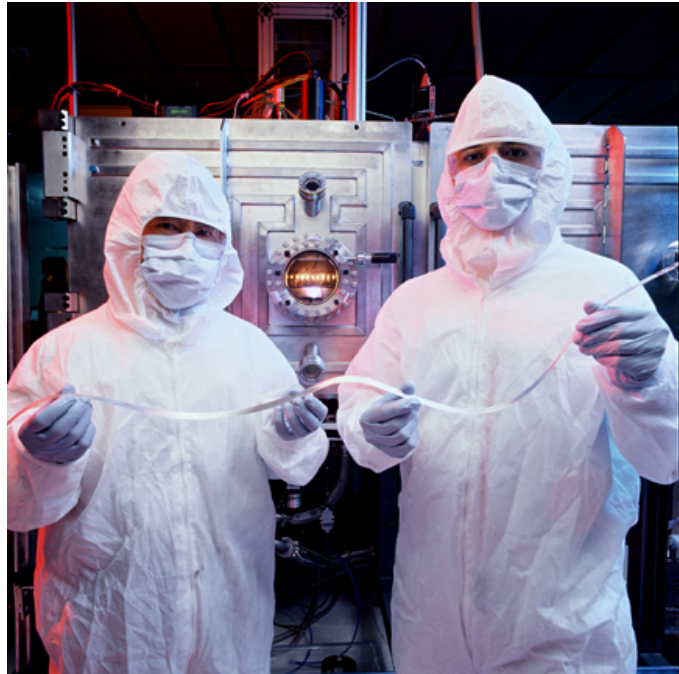


to continue the program for two additional years to further perfect the 2<sup>nd</sup> generation wire. (2Lt K. Schmaeman, AFRL/PRPG, (937) 255-6343)

DR. COHN TO SERVE ON CHURCHILL SCHOLARSHIP SELECTION COMMITTEE:

The Propulsion Directorate's Dr. Richard Cohn has been asked to serve on the selection committee for the [Churchill Scholarships](#). The Churchill Scholarship Program was created by the Winston Churchill Foundation of the United States to enable outstanding graduate students to study Engineering, Mathematics, and the Sciences at Churchill College, University of Cambridge. The selection committee will choose 11 students to participate in

this prestigious one-year program, which will result in the receipt of a Masters Degree (or equivalent). Dr. Cohn was a Churchill Scholar in 1991-1992 where he worked with [Prof. Michael Gaster, FRS](#),<sup>†</sup> to develop mechanisms to control boundary layer instabilities. (Dr. R. Cohn, AFRL/PRSA, (661) 275-6177)



Researchers holding a length of HTS wire



Dr. Richard Cohn was asked to serve on the selection committee for the Churchill Scholarships

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<sup>†</sup> Fellow of the Royal Society